XXI. *Observations on the Anatomy and Habits of Marine Testaceous Mollusca, illustrative of their mode of feeding.* *By* Edward Osler, *Esq.* *Communicated by* L. W. Dillwyn, *Esq. F.R.S.*

Read June 21, 1832.

In studying the Mollusca, we shall probably obtain more satisfactory results by tracing the organization connected with each important function through different classes of the animals, than by complete dissections of individual species. The data afforded by the first mode of investigation are more easily and effectually applied in future researches; and as they necessarily connect the study of function with that of structure, they enable the zoologist to infer with tolerable certainty those habits, which the pelagic character of the animal, or his inability to procure living specimens, prevent him from observing.

Thus examining the mollusca in detail, we shall find no part of their organization so interesting as that by which they take their food. Affording a general basis for scientific arrangement in the higher departments of zoology, it must be a still more certain key to the habits and general structure of those lower classes of animals in which the greater part of the organs are directly connected with this function.

We ought not to be surprised that so little has hitherto been done to elucidate the subject. The dissection is very difficult, from the small size and great softness of the parts; and its results are often deceptive, for it is not always easy to determine whether any particular appearance be natural, or caused by the knife. The microscope affords very little assistance in distinguishing the parts already dissected, and would be productive only of embarrassment in the attempt to display them.

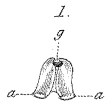
Cuvier, in his work on the Mollusca, leaves this part of his subject nearly untouched. His allusions to it are for the most part but vague generalizations; and where he enters into detail, as in the trunk of *Buccinum undatum*, he falls continually into error.

In the descriptions I have to offer, and in the drawings by which they are illustrated, I propose to guide the naturalist through the successive stages of a dissection which may enable him, without much difficulty, to display the parts for himself. Where the subjects are so very small, no care will always prevent oversights, and even errors; and after every precaution to ensure accuracy, it is probable that I may be corrected in some points by naturalists who enjoy opportunities for dissecting recent specimens of the larger tropical mollusca. I wish therefore to show how the different parts may be displayed without injury; or at least, by what mode of dissection I have arrived at my own conclusions.

The herbivorous mollusca which I have examined have three distinct modes of feeding. They browse with opposite horizontal jaws—they rasp their food with an armed tongue, stretched over an elastic and moveable support—or they gorge it entire. *Trochus crassus* is a convenient example of the first; *Turbo littoreus* of the second; and *Patella vulgata* of the third.

Trochus crassus is furnished with a pair of cartilaginous jaws, whose superior margins are thickened and rounded; and which are so united by a ligament along their inferior edges, that they open and close like a book. A small accessory cartilage is loosely connected by a ligament to the posterior extremity of each. Between the jaws, and extending about half an inch beyond them, is the tongue, not flat, as in Turbo, and Patella, but folded into a semi-cylinder, and whose margins are furnished with a membrane which is expanded over the rounded upper edges of the jaws. The tongue is armed on either side with a series of imbricated and lamellar teeth, waved like an Italic *f*, set in a direction obliquely forward and downward, and whose serrated edges incline backward. The space between these opposite series, which forms about two fifths of the breadth of the tongue, is set with corresponding transverse rows of small sharp teeth, whose points have a direction similar to that of the lamellar ones. The tongue, thus arming the opposite jaws, is secured in its place by the lingual membrane, and by the muscles inserted into it.

The movements of the jaws and tongue are effected by three sets of muscles. The first of these (Plate XIV. *b*, fig. 2 and 3.) occupy all the face of the jaw, and are inserted along the lingual membrane, and around the inferior half of the mouth. Their lowermost fibres on either side, inserted into the extremity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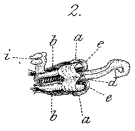
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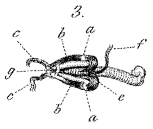
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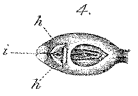
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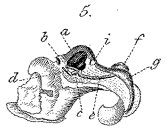
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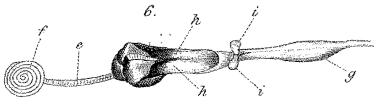
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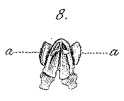
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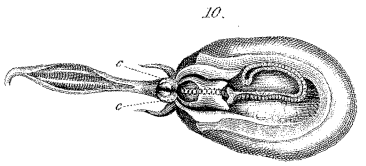
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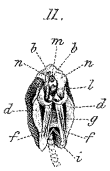
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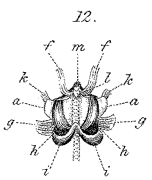
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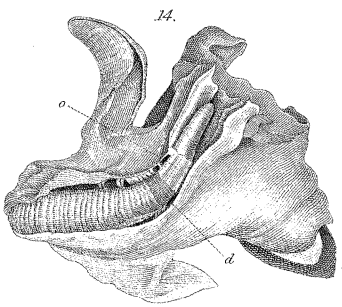
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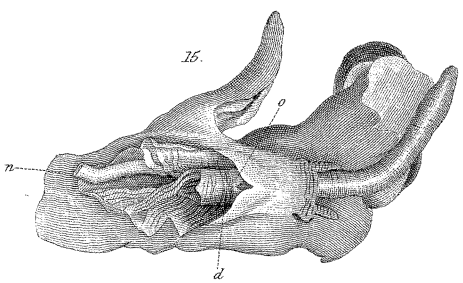
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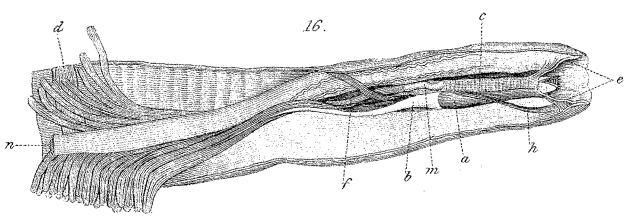
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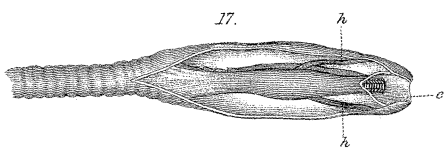
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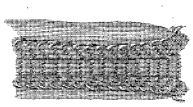
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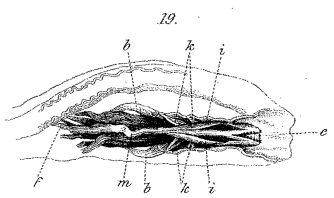
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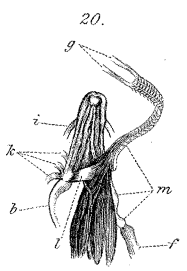
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of the lingual membrane, may be considered as distinct muscles, and I have figured them accordingly (*c*, fig. 3.), for they are readily distinguished in their course, and admit of being displayed separately by dissection. The action of the whole mass will project, and expand the jaws, and at the same time raise and throw forward the tongue. The jaws are closed by the transverse muscle, (*d*, fig. 2.); and the portion of food they have seized is cut away by a retraction of the tongue, effected by a third pair of muscles inserted into its lower part, (*e*, fig. 2 and 3.), and which, arising from the accessory cartilages, pass around the jaws, and run forward and upward to their insertion.

The teeth are rolled in a longitudinal direction, and to such an extent, that their inserted as well as their free edges are directed backward. Thus they form so many springs, which, yielding at first to the resistance of the food, will afterwards, by their elasticity, throw back towards the stomach the portion they have separated.

The stomach rests upon the jaws, opening directly over their active portion, without the intervention of any œsophagus. A pair of triangular lips project from its opening, and dip between the jaws to receive the food. In front of these is a double semi-cartilaginous valve, resting upon the fore part of the jaw, apparently furnished with some minute muscles, and which appears calculated, not merely to prevent the escape of any fragments of food, but also to bring them within reach of the lips. A pair of prominent parallel ridges are continued backward from the lips into the stomach for two thirds of its length, which, as they form a complete tube by closing their edges, may be considered as an internal œsophagus. I am not aware that a structure corresponding generally to this has been previously noticed.

To display all these parts, the mantle and spire are first to be removed, and the integuments of the body divided from the muscle of the spire on either side as far as the tentaculæ. The extremity of the tongue, which crosses the body from right to left, a little behind the jaws, is now to be disengaged. The detached integuments, with the viscera adhering to them, are next turned forward as far as the attachment of the stomach to the jaws; in doing which we divide a small muscle on either side, which secures the stomach. Raising the jaws by the extremity of the tongue, and dividing some delicate ligaments which connect them with the floor of the cavity, we have brought into view

all the muscles already described; and the insertion of the retractors of the tongue will be seen, as in fig. 3, by dividing the ligament which unites the jaws. There are, in addition, a small muscle (*f*, fig. 3.) passing forward from the tongue to be inserted into the floor of the cavity on the right side; a pair of delicate muscles, not figured, which arise from the posterior part of the jaws, and pass forward over the lateral muscles to be inserted near the sides of the mouth; and a very small one (*g*, fig. 1. and 3.) which occupies a hollow near the point of the jaws, and assists in expanding them.

The stomach may now be turned forward, detached from the jaws, and opened longitudinally on the under part. The contained œsophagus, the lips, with a pair of very small internal lips between them, and the valves in front, will then be seen, in a favourable specimen, as in the figure.

The nervous system, which in some of the mollusca embarrasses the dissection from its size, is here very inconsiderable: indeed, it is only by a very careful examination that it can be discovered. A pair of very small ganglia at the base of the tentaculæ are connected by a cord which crosses the fore part of the stomach. A filament surrounds the attachment of the stomach to the jaws, and another runs along the left side to the back of the same organ, which it nearly crosses. The whole will be displayed by carefully detaching the integuments from above; but this is a task of extreme difficulty, for the stomach is almost of a pulpy texture, and tears with the slightest force.

In *Turbo littoreus*, the parts are far more simple than in Trochus; and the dissection, notwithstanding their very small size, is attended with fewer difficulties. The body being cleared from the spire and mantle, the integuments are to be completely cut away, as in fig. 5, leaving the contained parts in their natural situation upon the muscle of the spire. The fleshy mass connected with the mouth, which in the largest specimen scarcely exceeds the size of a hemp-seed, will then be seen in front, with the œsophagus cresting it, and running back to its termination in an elongated stomach. The extremity of the tongue, wound into a compact spiral, rests upon the stomach; while the salivary glands, a soft, yellow, granular substance, occupy the space between the spiral and the mass of the mouth. All these parts are to be distinguished through the integuments. The chief caution to be observed in this stage of

the dissection is to avoid entangling the point of the knife in the spiral of the tongue.

Having carefully removed the salivary gland, we expose a very considerable nervous system. A plexus, attached on either side at the base of the tentaculæ, passes around the back of the fleshy mass, as if to secure it, being involved in such a quantity of a dark-coloured substance as to appear almost like a muscle. Two others, in which the nervous filaments are rather more distinct, are attached to the projecting ears of the œsophagus, and pass to the floor of the cavity. The whole is to be cleared away, and the parts will then appear as represented in fig. 5.

In this figure, the dark fleshy mass is seen in its natural position upon the muscle of the spire. The tongue, marked *e*, passes from under it, and runs back to its termination in the spiral *f*. The œsophagus, distinguished by its prominence and colour, is traced from the mouth, and one of its ears is seen at *i*. Under the fleshy mass are three muscles: a small one, *c*, arising from the tongue, and inserted into the middle of the floor of the cavity; another, *d*, arising by a double origin from either side of the insertion of the preceding, and running forward to blend with the sphincter of the mouth; and a pair of considerable ones, which cover the base of the fleshy mass, arising from its posterior part on either side, and terminating by a broad insertion immediately below the sphincter. The last, whose situation is indicated at *b*, are evidently the muscles upon which the act of feeding depends.

The stomach is now to be turned forward; and with very little assistance from the knife, the œsophagus will be separated from its loose attachments, exposing the internal parts, as in fig. 6. In the centre appears a considerable prominence, broad and flattened behind, and narrow on its crest and in front; along which the active portion of the tongue is stretched, and over which the lingual membrane is expanded. The back part is divided down the centre by a deep vertical groove, in which the continuation of the tongue is buried. The pharynx is furnished with a pair of strong longitudinal muscles, (*h*,) which arise from the upper part of the mouth; and the stomach when laid open, presents a series of transverse prominent ridges, which cover every part, except a deep channel extended from the œsophagus to the intestine.

The dissection will be completed by turning back the lingual membrane,

and dividing a delicate expansion down the groove which the tongue had occupied. The divided membrane will immediately slip down, and expose a pair of elastic bodies, set, like acorns in their cups, in a thick base, from which this membrane is expanded to cover them. A process from the base is given off from between them, forming a loop, through which the tongue passes. The elastic bodies are narrowed in front, where they are connected by a vertical band; and they are united to the base in which they rest, only at a small point anteriorly, their larger posterior portions being free. The apparatus is represented, fig. 7, in which the elastic bodies are separated to show the membrane which connects them in front.

The tongue, a flat strap-shaped organ, is more than two inches long. It presents three longitudinal ranges of teeth, which recline backward, and are set like scales, with very little elevation of their edges. In the two outer rows, the teeth are single, irregularly crescentic in shape, and set by their convexity: in the middle one, each transverse range contains several, which are small, and nearly square. All are too minute to be distinguished, except under a high magnifying power. The magnified lingual membrane appears beautifully reticulated.

From a consideration of the whole structure, the action of the parts may be readily inferred. The contraction of the broad muscles brings the lower and posterior part of the fleshy mass forward; and the tongue, thus thrown backward with a circular motion, will act effectively upon the food which the external lips have brought within its range. It is probable that the contraction of the columnar muscles of the pharynx is synchronous with this motion, as the opening into the œsophagus would thus be advanced to receive the portion cut away. The reaction of the elastic bodies, which are necessarily compressed in effecting the stroke, will restore the parts to their former position.

Turbo littoreus feeds upon the softest algæ. I have observed it devouring a minute filament, which entered the mouth by a succession of jerks, repeated at very short intervals. In this case it is probable that the filament passes undivided into the stomach. When browsing upon larger fragments, the portions cut away are so very small that the impressions left can be seen only by a close inspection.

It is not to be questioned that *Patella vulgata* has considerable power of locomotion. I have taken one from the side of a recently stranded wreck, some feet above the beach; but it is certain that it often remains for life on the same spot. Large specimens are always to be found adhering to an irregular and naked rock, with their shells distorted in exact correspondence with all its inequalities. In such situations they necessarily depend for their food upon the fragments floating in the water; and on the rocky shores where they are found they will derive an abundant supply from this source. The little eddy which plays around them from the motion of the tides and waves, will, when the shell is raised from the rock, bring any floating fragments within reach of the lips.

Patella gorges its food entire. This fact might have been inferred from its anatomy, and it is proved by observation. Some time since, Mr. Dillwyn and myself, dissecting some specimens, found in the stomach of one of them a portion of a fucus so large, that he was enabled at once to recognise it as *F. pinnatifidus*; and in a recent communication he informs me that he has found fragments of *Ulva linza* in the stomachs of others. It is not however to be supposed that Patella never feeds upon growing marine plants: indeed I have seen it in the act of preying upon the soft dark substance so often found covering the shell of *Trochus umbilicatus*.

The jaws of Patella are furnished with a skeleton far less simple than that of Trochus. A pair of triangular cartilages, which I shall call the "lateral jaws," are united by a ligament along their base to the point, and each has a smaller "posterior cartilage" articulated with its extremity. A pair of "accessory cartilages" of the size and shape of linseed, rest, with their thicker extremities forward, on the outside of the lateral jaws. Corresponding with the centre of these, within the jaws, arise a pair of elastic and pyriform bodies, which sink between the expanded jaws, and rise above them when closed. In addition to this apparatus, there is a bony upper jaw, formed of a central portion, whose figure is the vertical section of a hollow cone, with a pair of broad processes like wings given off from its sides; and with a distinct and moderately broad margin, whose extremities are free, surrounding the base. The muscles of the pharynx arise from the superior edge of the upper jaw, and the active portion of the tongue corresponds with its concavity.

The tongue is more than four inches long. Running over the opening between the lateral jaws, it dips behind them, passes along a deep hollow in the foot nearly to the extremity of the animal, is then brought in a curve upward and forward under the investing membrane of the body, and finally, doubling on itself, returns to the posterior part of the jaws, where its extremity is attached. Like the tongues of nearly all the mollusca, it becomes soft towards the end. The teeth are strong, prominent, and erect, with the points curved backward. They are set four together in transverse rows, so compactly, that they appear as if united. The distance between these rows is equal to two thirds the breadth of the tongue; and in their intervals on either side are other rows, disposed obliquely, and with two teeth in each. The principal lingual membrane, into which the muscles are inserted, is attached along the upper part of the accessory cartilages; but there is in addition a proper one, resting upon the other, and which alone is so firmly attached to the tongue as to admit of being removed with it.

In the act of feeding, Patella opens the mouth laterally. The integuments, adhering firmly to the bony upper jaw, expand the free extremities of its margin, and separate a pair of soft lips attached within these extremities, whose opening is of course vertical. A single large and complicated muscle now closes the jaws, and retracts the tongue, whose hooked teeth draw up the food to the opening of the pharynx. Increased effect is given to this action, partly by a pair of muscles inserted into the wings of the upper jaw, which press its concavity against the teeth; and partly by the projection of the elastic pyriform bodies, which raises the tongue above the level of the lateral jaws. The parts will be restored to their original position, and the cartilages at the same time moderately expanded, by three pairs of small muscles; of which the first (*e*, fig. 13.) act upon the upper jaw; the second, (*k*, fig. 12.) upon the accessory cartilages; and the third, (*f*, fig. 11. & 12.) upon the extremity of the tongue itself.

In dissecting the parts, we begin by removing all the soft portion, comprehending the liver, ovarium, and intestines. The tongue is to be carefully disengaged, and it will be right to preserve the stomach, which is found without difficulty, on the left side, resting on the ovarium. Having divided and turned aside the integuments of the head, and thrown the stomach forward, separating

the pharynx from its attachments as far as the upper jaw, we shall have exposed the parts as in fig. 10.

In this figure we observe a muscular apparatus in the pharynx similar to that of Turbo, each columnar muscle having a valvular appendage connected with it, which appears to close the opening. The active portion of the tongue is seen on the part which the pharynx had covered, and surrounding this part is an irregular edge, representing the loose membrane from which the pharynx had been separated, and which, acquiring a firmer attachment as it recedes, is at length blended with the muscles. The accessory cartilages cause the breadth of the jaws in front, and the posterior cartilages are marked by the rounded projections between which the tongue descends. None of the muscles can be distinctly displayed in this view.

Raising the whole mass, a number of small muscles are seen passing forward from the extremity of the jaws to the floor of the cavity, and forming two series; the first, inserted across the middle of the cavity; the second, which appears as a single broad muscle, a little within the mouth. The whole are to be removed, and the jaws may be detached altogether.

A pair of very thin muscles (*e*, fig. 13.) may now be traced passing from the posterior extremities over the accessory cartilages to the wings of the upper jaw, which they raise. Underneath appears a broad straight muscle, whose fibres, as it advances towards the mouth, separate to either side, exposing a yellow-looking mass, which might be mistaken for a gland, but which is an extension of the soft lips forming a considerable cavity. Within this cavity are found the extremity of the tongue, and a small conical papilla, striated transversely, which terminates the lingual membrane, and which is probably the organ of taste, as I observe it to be constantly thrown forward in the act of feeding. The cavity is to be laid open; and the muscles being divided and turned aside, the parts will appear as in fig. 11.

All the principal muscles are now exposed. Those which have been turned aside (*d, d*) are inserted into the wings of the upper jaw, which they depress and retract. The narrow straight muscles (*f, f*) arising from the extremity of the posterior cartilages, pass on beneath the cavity of the mouth to the extremity of the lingual membrane. Near the insertion of these muscles their outermost fibres separate, and pass to the attachment of the pharynx, behind

which they are united, forming for it a sort of sphincter. There is a minute muscle between *f*, *f*, which, to prevent confusion, I have not figured along its whole course; it is inserted under the lingual papilla, which it retracts. The transverse muscle *g*, and the oblique ones seen between the jaws, are portions of the great retractor of the tongue.

To display this muscle, the upper jaw with its muscles, and the walls of the cavity of the mouth, are to be removed; and the muscles *f*, *f* detached, and thrown forward. Having divided and turned aside the transverse fibres, *g*; separated the ligamentous attachments which secure the lower edges of the accessory cartilages; and cut the muscles *k*, *k* which throw the cartilages forward, we may slip out the jaws, and display the muscle as in fig. 12. It is composed of three distinct portions;—the transverse fibres *g* which embrace and compress the lateral jaws; a straight column on either side *h*, attached along the under surface of the lingual membrane; and the oblique portions *i*, *i*, which, like the retractor muscles in Trochus, pass around the posterior cartilages, and run forward to be inserted into the tongue itself. The only attachment of this muscle to the jaws being at the extreme points of the posterior cartilages, it is enabled to play over them with the greatest freedom.

Chiton appears to feed like Patella, but there is considerable modification in the structure of the parts. A pair of simple lateral jaws, rather membranous than cartilaginous, constitute the whole skeleton. The tongue is projected around the point of these jaws by a pair of muscles corresponding to *f*, *f*, fig. 11. and 12; and is retracted by three pairs of powerful muscles; of which two agree with *h*, *h* and *i*, *i*, fig. 12; while the third, arising from the tendon of the second valve of the shell, is inserted into the upper part of the tongue. Between the insertions of the last pair is the opening of the pharynx. The tongue is set on either side with two rows of large teeth, of which the inner present the form of circular discs, with very blunt edges; the outer, corresponding to the interstices of the first, are prominent and falciform, with the points directed inward. The space between the inner rows is armed with ranges of smaller teeth. Under the opening of the pharynx, the tongue enters a sheath, in which its opposite edges are closely folded together. It consequently expands as it passes over the point of the jaws, and closes when retracted. Occupying the centre of the mouth is a large solid papilla, with an

expanded cup-shaped extremity. It is furnished with an apparatus of muscles, and is probably a gustatory organ, like that already noticed in Patella. The extremity may, perhaps, act as a sucker, to seize the food, and convey it to the tongue.

I have observed a third modification of a structure fitted for gorging food, in a small Patella from the West Indies (*P. mammillaris*, Linn.). There is simply a very muscular mouth and pharynx; and an elastic mass very closely resembling that in *Turbo littoreus;* but neither cartilage, tongue, nor hard parts of any description.

In all the display of instinct there is perhaps nothing more extraordinary than that an animal, whose senses appear to be of the most imperfect description, should laboriously and patiently drill through a shell to obtain its food; and in the whole range of human and comparative anatomy, I am acquainted with no structure more complicated than the instrument by which this penetration is effected. The fact itself is noticed by PLINY; and although it has been questioned by some modern naturalists, while I am not aware that any have confirmed it by their own observation, it may yet be witnessed on the shores almost at any time. One of our most common littoral mollusca, *Buccinum lapillus*, feeds in this manner; and whenever it is seen attached to another shell-fish, with the foot slightly projected and expanded, a more or less advanced perforation will be found. On the shores at Swansea, its common prey is the muscle; and it sometimes, though rarely, attacks the oyster and anomia. Around Falmouth, it feeds chiefly on the limpet, but will occasionally be seen upon Turbo, Trochus, Nerita, and even its own species*.

The perforation is effected by a succession of strokes, following each other at intervals shorter than a second. I have distinctly heard them by applying to the ear a Patella which I had carefully removed from the rock, with a Buccinum attached to it. The process is extremely slow. I have found it still incomplete after having watched it for some hours. When the perforation has been effected, the prey is not immediately destroyed by any poisonous secre-

* Mr. DILLWYN's observations lead him to suppose that *Buccinum lapillus* commonly feeds on the Balanus. I have never seen anything to confirm this opinion, and believe the prey to be much too small for the full-sized Buccinum; but I constantly observe small specimens in situations where they could scarcely obtain any other food.

tion; at least, I have kept alive for some days a muscle which the Buccinum had begun to eat. The trunk is therefore projected at first through the hole which it has drilled. But when, from the death of the animal, the limpet separates from the rock, or the bivalve gapes, the Buccinum devours the remainder by the natural opening.

The slow penetration of *Buccinum lapillus* is explained by the weakness of the instrument, which is so small that I have not been able to dissect it. My description of this extraordinary weapon must therefore refer to that of *Buccinum undatum*, in which the parts are sufficiently large to admit of being shown distinctly.

Since this species undoubtedly feeds on carrion,—for it takes the fishermen's baits, while, from its semipelagic habits, it is never seen in the act of boring a shell-fish,—some proof will be required that it really feeds in this manner. It would probably be sufficient to state, that the shores of sandy bays, in which *Buccinum undatum* abounds, are strewed with immense quantities of perforated shells of the bivalves inhabiting sand; and that the perforations in these are much larger than could be effected by *lapillus*, which indeed is never found upon sandy shores. But I once obtained a decisive proof, in witnessing a *Buccinum undatum* discharge with its fæces the extremity of the foot, and the tubes of a *Lutraria compressa*.

Cuvier, in his Anatomy of this animal, has given a description of its boring trunk, illustrated by six figures; and I may be required to explain why I go over the same ground. It will be sufficient to state, that his description of all the more essential parts is vague, defective, and erroneous. The cartilages he represents, fig. 12, have no existence, and several of the most important muscles are overlooked. His different figures are not even consistent with each other. Thus, in fig. 10. the opening of the trunk is represented as a vertical slit, forming a pair of armed lips, and he describes it accordingly at p. 3; while in fig. 7, 8, and 9, it is correctly shown as a terminal and circular orifice.

The tongue of *Buccinum undatum* is about an inch in length, strap-shaped, and set with three longitudinal rows of teeth, which are short and straight in the centre, but large and hooked on either side, forming a perfect centre-bit. The disposition of the teeth is shown in fig. 18. The portions of the tongue which support the outer rows of teeth fold over upon the centre, and allow the

instrument to be conveniently received within a membranous sheath. Into this sheath the muscles are inserted; and the tongue, issuing from its opening, is expanded and stretched over two cartilaginous points. A pair of small muscles inserted into the extremity of the tongue maintain it firmly in its position.

The tongue, with its apparatus of muscles, is contained within a strong membranous tube, which, at its posterior extremity, is doubled back upon itself; thus presenting a containing and a contained portion, so disposed, that in projecting the trunk, the contained portion is elongated at the expense of the other. The trunk is projected by a series of annular muscles, closely set along the whole of the containing tube; and it is retracted by a multitude of longitudinal ones, which, arising from either side of the cavity of the body, are inserted along this tube over their antagonists. The active extremity of the tongue is embraced and projected by a funnel-shaped muscle, arising from around the aperture of the tube, and which, at its upper part, is blended with the pharynx. The œsophagus rests upon the muscles of the tongue, and issuing from the extremity of the trunk, is doubled, and runs forward as far as the origin, or attachment of the containing tube; then, forming a second double, it passes back to the stomach. Such a mechanism was necessary, to allow the œsophagus to be projected with the trunk.

The muscular apparatus of the tongue is supported by a part which I shall call "the base." It presents the section of a cylinder, secured by two muscular crura. Its structure is chiefly membranous, with transverse muscular fibres, and with a double muscular column on either side. The inner columns are united at about a line from the point of the base, and their margins are free along their whole length; but the outer columns extend to the extremity of the base, and being tipped with cartilage, form the support over which the tongue is stretched. The opposite margins of the base itself are connected with transverse muscular bands, beneath which they give origin to five pairs of oblique muscles, which are inserted into the sheath of the tongue. A mass of longitudinal muscles pass between the crura of the base to be inserted into the back and sides of the sheath.

After this general description, the mechanism of the trunk will be sufficiently understood by a reference to the figures which illustrate the successive stages of a dissection. In fig. 14. we have the Buccinum cleared from the

spire, mantle, and branchiæ, and laid open in a direction corresponding with the longitudinal axis of the body. The trunk is displayed in situ, with its extremity issuing from the containing tube, and resting at the aperture of the mouth. The annular muscles are seen on the containing tube, the last of the series being distinguished from all the others by its size and colour. The origins of some of the muscles of the trunk are perceived on either side.

In fig. 15. the trunk is projected to its full extent. The curvature and unequal thickness of the extended portion are quite characteristic. The multitude of muscles which arise from either side of the body, and especially from the right side, are seen entering the extremity of the trunk, while the œsophagus passes out from underneath them.

Removing the trunk from the body, and opening it down the side, we shall display the upper part of the tongue, with its muscles, as in fig. 16. The œsophagus is thrown with the divided tube to the left side, and the tortuous salivary ducts are seen passing along its under surface to the pharynx. Behind is the great annular muscle, *d*, with the mass of muscles which run forward to be inserted along the tube and into the tongue. The muscles where they arise from the body, as well as all those inserted into the tube, have the pearly bluish tint common to the muscular fibre of fishes; but the great annular muscle, and all inserted directly into the tongue, are of a red colour. Anteriorly at *e*, is the funnel-shaped muscle which projects the active portion of the tongue. The base is marked *a*, one of its crura *b*, and the muscular bands which connect its opposite margins *c*. Under these transverse bands, and issuing from behind them, is the sheath of the tongue, tortuous, and with a considerable muscle attached to its extremity; while beneath it, and within the crus of the base, are the long muscles which are inserted into it. The thin flat muscle *h*, given off on either side from near the extremity of the tube, and taking a somewhat oblique direction backward to be inserted into the base, probably assists in projecting and rotating the tongue.

Fig. 17, in which the tube is opened along its under part, displays many of the muscles represented in the preceding. They are distinguished by the same letters. The posterior part of the tube is contracted into annular folds by the corresponding muscles; and anteriorly, the tongue, having been stretched over the cartilaginous points of the base, is doubled back, its extremity being

concealed under the insertion of the funnel-shaped muscle. A highly magnified view of this part of the tongue is given in fig. 18.

Reverting to the state of the parts in fig. 16, we divide the transverse bands of the base, and thus display the internal parts as in fig. 19. The sheath of the tongue is now fully exposed, with four pairs of oblique muscles inserted into it; of which one pair, *i*, take a direction backward, the others, *k*, *k*, forward.

Finally, in fig. 20. all these muscles are cut, and the tongue itself thrown aside. A deeper-seated pair of broad oblique muscles, *l*, and the insertions of the longitudinal ones are thus brought into view; while the internal structure of the base itself, with its muscular columns, and the cartilage with which the external ones are tipped, may now be conveniently examined.

The trunk of *Buccinum lapillus* must not be supposed to differ from that of *undatum* only in its size. It is essentially distinct in many points; but I shall not attempt a description on the accuracy of which I could place no reliance. The trunk of *Murex echinatus* appears to be of the same kind; presenting but a small mass of muscles at the very extremity of the tube. Some of the large tropical Murices will probably enable us to determine the anatomy of this variety. In the trunk of *Buccinum reticulatum*, we may trace without difficulty a very close conformity to the type of *undatum*, though the diameter of its muscular apparatus does not exceed that of a small pin.

There is another branch of the subject, into the details of which I shall not enter at present, but whose importance may claim a brief notice. In the modern systems of conchology, a beaked shell is considered to indicate a carnivorous animal; while an entire aperture is regarded as an equally unexceptionable mark of a herbivorous one. The first, I believe, is not to be disputed. There appears indeed no necessary relation between a respiratory tube and a boring trunk; and it may be curious to inquire why some of the carnivorous trachelipodes, *Buccinum undatum* and *reticulatum*, Cypræa, and others, carry their respiratory tube projected in an arch; while in *Buccinum lapillus* and Murex, it is lodged in a channeled beak: but there can be little doubt that all the beaked spirivalves are predatory. The opposite conclusion however is quite untenable; and the well-known example of Ianthina would alone be sufficient to overturn it. Although this molluscum cannot pierce shells, as

Cuvier states, for the obvious reason that it is itself the only floating shell-fish; and although its trunk is very unlike that of *Buccinum undatum*, to which he has compared it, its anatomy can leave no doubt of its carnivorous habits. Yet its aperture is entire, for the absence of anything like a respiratory tube forbids the extension of the columella from being considered as a beak.

Or if the columellar extension in Ianthina should be held to destroy the value of the exception, the aperture of *Natica glaucina* is perfectly entire, and this molluscum is certainly carnivorous. It devours the baits set by fishermen near low water mark; its fæces are slimy, and it is furnished with a considerable trunk, which bears a close resemblance to that of *Buccinum lapillus*, except in being less projectile, and is actually larger in proportion to the size of the animal. It is but reasonable to suppose that many other mollusca, marked with the same external characters, possess a similar structure and similar habits; and consequently, that the presence or absence of a beak is too exceptionable to be received as a distinction between the carnivorous and the herbivorous classes.

I suspect both Ianthina and Natica to be insectivorous. The latter is nearly a pelagic animal, and is never met with far from low water mark, except when thrown on shore by storms. The foot is large, composed of several lobes, and capable of being injected with water; and the animal is usually found, when under water, with the shell buried in the sand, while the injected foot rests like a mass of dead fish on the surface. May not this be a bait, to attract the prey which the animal is unable to pursue; and is it not probable that the extraordinary vesicular appendage of Ianthina may have a similar object?

This view of the subject receives support from the situations in which the animals are found. Floating helplessly on every part of the ocean, it would appear that Ianthina can obtain no food but the insects decoyed within its reach. The sandy bottoms, which are the haunt of Natica, afford no marine plants; it would rarely obtain carrion; and its tongue, closely studded with rounded tubercles, appears not at all calculated to penetrate shells.

To determine with exactness the anatomy of the organs of feeding in these animals, as well as of boring-trunks analogous to that of *Buccinum lapillus*; the nature and action of the digestive organs in the Bulla tribe; and the mode

of feeding in the different land and fresh-water mollusca, will probably complete the general outline of this branch of zoology. Should leisure and opportunity allow, I shall hope to pursue the investigation.

I must not conclude without acknowledging my very great obligations to Mr. DILLWYN. His observations on fossil shells, published in the Philosophical Transactions, first suggested the inquiry; and the use of his valuable library, and still more, his own extensive information, have materially assisted me in the execution of it.

Explanation of the Plate.

PLATE XIV.

Trochus crassus.

Fig. 1. The cartilaginous skeleton of the jaws.

Fig. 2. Upper view of the jaws, with the tongue and its muscles.

Fig. 3. Under view; the ligament of the jaws divided to show the insertion of the retractor muscles of the tongue.

Fig. 4. The stomach, laid open to display the contained œsophagus.

a. The accessory cartilages.

b. The muscles which expand the jaws.

c. Portions of them which project the tongue.

d. The transverse muscle which closes the jaws.

e. The retractors of the tongue.

f. A muscle passing from the tongue to the floor of the cavity.

g. A small muscle which assists to expand the jaws.

h. The lips of the stomach.

i. The valve in front of them.

Turbo littoreus.

Fig. 5. The fleshy mass of the mouth, with its muscles, the tongue, and the stomach, in situ.

Fig. 6. The pharynx detached, and the stomach turned forward, to display the tongue stretched over its elastic cushion.

Fig. 7. The elastic bodies which form the cushion.

a. The fleshy mass of the mouth.
b. The muscle which acts upon its base.
c. The muscle of the tongue.
d. The muscle of the sphincter.
e. The tongue.
f. Its termination in a spiral.
g. The stomach.
h. The muscles of the pharynx.
i. The earlike processes of the œsophagus.

Patella vulgata.

Fig. 8. The skeleton of the jaws.

Fig. 9. The upper jaw.

Fig. 10. The jaws, with the tongue and its muscles, in situ.

Fig. 11. Under view of the muscles.

Fig. 12. The retractor muscle of the tongue.

Fig. 13. Insertions of the muscles of the upper jaw.

a. The accessory cartilages.
b. The upper jaw.
c. The muscles of the pharynx.
d. The depressors of the upper jaw.
e. One of its levators.
f. The extensors of the tongue.
g. The transverse fibres of the retractor, which compress the jaws.
h. The columnar portions of the retractor.
i. Portions of the retractor which pass round the posterior cartilages.
k. Muscles which throw forward the accessory cartilages.

l. The lingual papilla. (The insertion of its retractor muscle is seen underneath it in fig. 11.)

m. The point of the tongue.

n. The soft lips.

Buccinum undatum.

Fig. 14. The trunk, in situ.

Fig. 15. The trunk developed.

Fig. 16. Upper part of the tongue, and its muscles.

Fig. 17. Under view.

Fig. 18. Magnified extremity of the tongue.

Fig. 19. Oblique muscles of the tongue.

Fig. 20. The base of the tongue.

a. The base.

b. Its crura.

c. Its transverse muscular bands.

d. The great annular muscle.

e. The funnel-shaped muscle which projects the tongue.

f. The muscle of the sheath.

g. The muscles of the point of the tongue.

h. The external oblique muscles.

i. The descending oblique.

k. The ascending oblique.

l. One of the deep-seated oblique muscles.

m. The sheath of the tongue.

n. The œsophagus.

o. Origin of the membranous tube which contains the tongue.

Of these, *a*, *b*, *c*, *e*, *g*, *h*, *k* and *l*, are not at all noticed by CUVIER, and the nature of *f* is mistaken.

Fig. 6, 7, and 18, are magnified; and 4, and 11, are a little larger than natural. The others are all of the size of the specimens from which they were copied.